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A Proposal for Treating Research and Development as Capital Expenditures in the Canadian SNA

by Meir Salem and Yusuf Siddiqi

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Executive Summary

This paper explores three key issues related to the capitalization of research and development expenditures in the National Accounts. First, it considers issues of scope of research activities and the range of investment activities that "should" be included as capital expenditures and reflected as part of productive capital stock and national wealth. It reviews the criteria and recommendations outlined in the Frascati Manual and the 1993 System of National Accounts (1993 SNA) to deal with issues such as whether to include "basic" research activities, and whether to include certain investments involved in industrial implementation of research and development (R&D). After considering the views of other contributors to the Canberra II Group, it recommends to include in capitalized R&D all patentable research conducted in the public sector and all research conducted in the business sector. In addition, it recommends that a wider range of investment activities be included in R&D capital than those suggested by the Frascati Manual. The recommended changes cannot be implemented with the existing data.

Next, the paper outlines steps that are required to transform Statistics Canada R&D data based on the Frascati Manual to accord with the 1993 SNA concepts and definitions in order to estimate R&D output by industry and R&D capital expenditures by industry and sector. The paper shows that capitalization of R&D based on existing Statistics Canada data would increase the level of capital formation by $15.8 billion or 7.7%, and raise total gross domestic product (GDP) by $12.8 billion or 1.2% for the year 2000.

In order to develop capital consumption and capital stock measures, the paper reviews issues and choices related to depreciation and deflation of the newly developed R&D investment series. It uses a perpetual inventory model and a geometric depreciation pattern with two alternative assumptions about asset life to calculate capital stock of R&D. The comparison shows that the growth rate of capital stock is not sensitive to the assumed length of asset life.

The paper concludes by recommending the creation of a satellite account for R&D/innovation outside the SNA core accounts. A satellite account would offer the flexibility of exploring alternative capitalization schemes that are needed at this point in the development of concepts and data sources.

1. Introduction

It is widely accepted that expenditures on research and development (R&D) by private and public organizations constitute a principal way in which organizations seek to improve their productive capacity and gain access to new products and processes. This perspective on the underlying motivation and the role of R&D spending stands in contrast to how it is represented in national economic accounts, where it has always been shown as current expenditures of public and private organizations. This treatment understates gross domestic product (GDP) for business industries and the sector as a whole where the results of R&D activities are shown as consumed in the same year that they are produced. Furthermore, treating R&D as current consumption keeps these expenditures out of the economy's capital stock, leading to an understatement of the amount of productive resources used each year by Business and Non-business sectors thereby overstating estimates of productive efficiency.

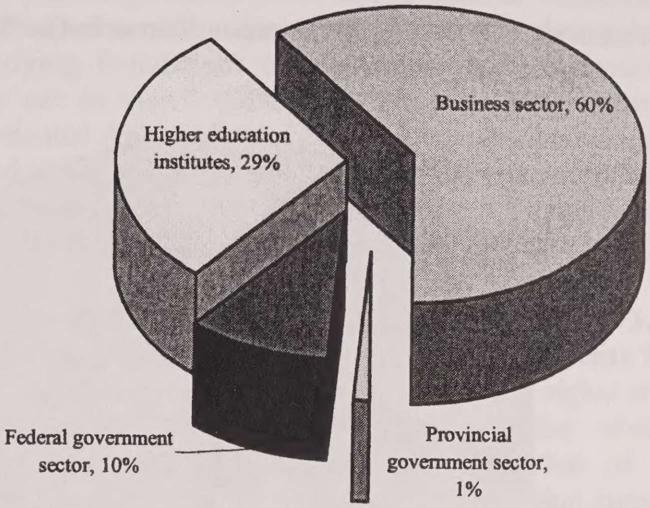
The 1993 System of National Accounts (1993 SNA) concurs with the view that R&D spending is "inherently investment".[1] However, treating these expenditures as capital formation in the Accounts is now being considered by the Canberra II Group for the up-coming 1993 SNA Revision-1. This paper deals with three aspects of an anticipated change in treatment: First, it deals with the series of adjustments that are needed to arrive at R&D expenditures by industry using data collected by Statistics Canada surveys and explores how this may impact existing measures such as GDP. Second, it deals with the issue of scope of what should be capitalized, ranging from a narrow definition of R&D based on the Frascati Manual to the much broader definition articulated in the 1993 SNA. Finally, it draws on these findings to recommend that a satellite account would be the most effective vehicle for extending the SNA's core accounts to incorporate innovation expenditures generally and R&D expenditures in particular.

2. Existing Statistics Canada research and development data

Statistics Canada has been publishing gross domestic expenditures on R&D (GERD) consisting of current and capital expenditures since the reference year 1963. Historical data on Business sector R&D were collected through surveys while governments and non-profit institutions (the Non-business sector) were covered using surveys and administrative records. They include R&D expenditures in Canada that are funded from abroad, and exclude Canadian expenditures which fund R&D activities outside Canada. These statistics are collected and compiled using the Frascati Manual guidelines. Starting with the 1996 reference year, data for firms with less than $1 million of R&D expenditures are obtained from tax records. The survey of the Business sector collects GERD, sources of funds and the breakdown of expenditures into basic research, applied research and developmental research. Information is also collected on payments made by industries for R&D cross-classified by broad groups of recipients.

1. SNA 1993, Par. 6.163. It elaborates that "Fixed assets are tangible or intangible assets produced as outputs from processes of production that are themselves used repeatedly or continuously in other processes of production for more than one year" (Par. 10.33).

Figure 1 Research and development expenditures by performing sector Canada, 2000



Source: Statistics Canada, Science, Innovation and Electronic Information Division.

For R&D performed by the Non-business sector, which in Canada consists of non-profit institutions and governments, the data are collected from survey and administrative sources. It does not provide a breakdown into basic, applied and developmental research which is available for the Business sector, but it does identify the sources of funds. Non-profit institutions and government entities that conduct R&D produce patented entities, but may also make their research freely available to the public, especially when the results have no apparent commercial potential. The performers of R&D are those institutional units which produce R&D by undertaking expenditures on intermediate and primary inputs, rather than those units that provide funding for R&D.

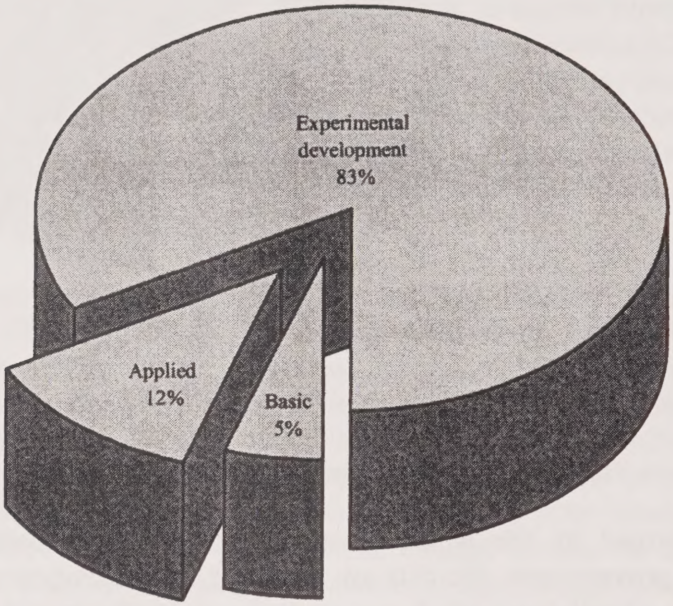
Expenditures on R&D gives rise to two kinds of products: so-called "market R&D" which is produced for sale to other industries, other sectors, or for export abroad, and "non-market R&D" which is produced by businesses on their own-account for final use.

Figure 1 shows the relative significance of current expenditures on R&D by performing sectors in 2000 as defined by the Frascati Manual. The Business sector performs 59.8% of all R&D, followed by universities with 28.8%. The government's share of total R&D is 11.4%, of which about 10% relates to the federal government.

The composition of R&D expenditures in terms of basic research, applied research and experimental development is only known for Business sector entities. These shares are shown in Figure 2. In Canada, by far the most dominant type of R&D expenditures is experimental development. It should be noted that while basic research makes up only about 5% of Business sector R&D, basic research is mostly conducted at universities and by governments which, in Canada, are part of the Non-business sector. The Non-business sector, as Figure 1 shows, is where 40% of all R&D expenditures take place. In the United States, basic research was about

7% of the total business sector R&D activity in 1997. At that time, basic research represented 66% of universities' R&D and about 25% of government's R&D expenditures.[2]

Figure 2 Types of research and development expenditures in the Business sector Canada, 2000



Source: Statistics Canada, Science, Innovation and Electronic Information Division.

3. The scope of research and development capital

The precise range of activities or expenditures that constitute R&D capital is one of the key conceptual issues. In terms of scope, the Frascati Manual's concept of R&D and the concepts of investment reflected in the 1993 SNA recommendations represent two somewhat different views that would lead to different estimates of R&D capital stock.

According to the Frascati Manual, the principal criterion for distinguishing R&D from related activities is "the presence in R&D of an appreciable element of novelty and the resolution of scientific and/or technological uncertainty" (OECD (1) 2002, p. 84). It states that "research and development comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications" (OECD (1) 2002, p. 63). It is clear from these criteria that activities intended to create new knowledge are included within its boundary, whether or not they affect the productivity of an economic process. This means that a wide range of basic

2. Data on R&D shares for 1997 were obtained directly from the Bureau of Economic Analysis (BEA). See also "A Satellite Account for Research and Development" by Carol S. Carson in *Survey of current Businesses*, November 1994-Volume 74, no. 11.

research conducted in the public sector which directly contribute to improving the well-being of human civilization are considered R&D even if they do not improve an existing product/process or introduce a superior product/process. The Frascati Manual classifies activities as Basic Research when they are "experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view" (OECD (1) 2002, p. 240). Other R&D activities are classified into purpose-oriented Applied Research which "creates knowledge that can be used to develop new or improved processes and products", and Developmental Research which "draws upon both applied research and earlier developments. New or improved processes or products come into being only at the end of the development process".[3]

The 1993 SNA views capital formation in terms of fixed assets (SNA 1993, 10.26). For an entity to qualify as an economic asset, the owner must derive economic benefits from holding or using it over a period of time, and the owner must enforce ownership rights over it individually or collectively. This would exclude many basic research activities which do contribute to productivity enhancement but do not meet the SNA's criterion of an economic asset. Specifically, research activities which supply the knowledge base that supports applied research would escape measurement as productivity-increasing capital expenditures if the strict SNA definition is followed. Recent views expressed on this issue include a study by Aspden (2003) which supports capitalizing all expenditures on basic research activities that indirectly contribute to society and another study by Harrison (2002) which suggests that some pure research undertaken at universities should not be treated as capital investment. However, business enterprises as a rule maintain and enforce ownership rights over the results of their research expenditures, thereby meeting the asset criterion of the SNA. Consequently, we find it compelling that when basic research is conducted in the Business sector, it should be treated as purpose-oriented research and capitalized along with other applied research. This view is also expressed by de Haan and van Rooijen-Horston (2004).

Some economists have suggested that publicly conducted R&D should not be capitalized because "once the resulting knowledge of (non-market) R&D is made freely available to the public, there is no ownership whatsoever, no market advantage of one agent over the other. As a result, this knowledge cannot be regarded as an asset in the economic sense".[4] This would presumably relate to basic research which has no apparent commercial use. However, some of the research that is conducted by governments and universities leads to patented entities and effectively becomes capital property. In addition, the outputs of these more basic forms of research are routinely used as raw knowledge material in successfully conducting R&D with direct impact on production and productivity. It is arguable that if basic research were not conducted, applied research would become more broad-based and, ultimately, encompass activities which are presently classified as basic research in order to produce the intended outcomes. Consequently, we propose to include basic industrial research that is *patentable*[5] in estimates of R&D capital investment rather than to leave them out completely. We argue that

3. "A Satellite Account for Research and Development" by Carol S. Carson in *Survey of current Businesses*, November 1994-Volume 74, no. 11.
4. Mark de Haan and Myriam van Rooijen–Horston, 2004, p. 29.
5. A research and development project is patentable if it is judged to produce products or processes with a commercial value.

patented and patentable basic research are investment activities that form the supporting foundation of applied research, and hence, of innovations in products and processes. This is similar to the treatment recommended by de Haan, and van Rooijen-Horston (2004, p. 18).

While it is clear from this discussion that R&D estimates based on the Frascati Manual might capture too broad a set of activities for what might be appropriate for National Accounts purposes like all types of basic research, it has been argued that it defines *too narrow a range* of investment activities. Specifically, the Frascati Manual excludes some expenditures of an investment nature such as patent filing and licensing, market research, manufacturing start-up and redesign of the manufacturing process (OECD (1) 2002, p. 110). Baldwin et al., (2005) argue that the Frascati Manual excludes considerable investment expenditures which "support industrial innovation". To underline the importance of these costs, they cite the findings of a Statistics Canada special survey of entrants—the 1996 Survey of Operating and Financing Practices—that "R&D was 30% of the total investment whereas, acquisition of technology, market development and training were 22%, 18% and 11% respectively". They also cite the breakdown of innovation costs reported in Statistics Canada's 1993 Survey of Innovation and Advanced Technology which showed that R&D accounted only for 47% of total costs, whereas 53% of innovation costs were made up of technology acquisition (patents, trademarks, licenses, specialist consulting services, disclosure of know-how, adding up to 10%), manufacturing start-up (34%) and marketing start-up (9%) (Baldwin et al., 2005, p 16). The argument that these expenditures should be capitalized as part of R&D capital is persuasive. Clearly these expenditures have both a long-lasting effect on economic production and make a positive impact on industrial productivity, both important SNA criteria as we will see in the following discussion.

The view expressed in the 1993 SNA is that R&D "is an activity undertaken for the purpose of discovering or developing new products, including improved versions or qualities of existing products, or discovering or developing new or more efficient processes of production (SNA 1993, Par. 6.142). It further recognizes that R&D activities are "undertaken with the objective of improving efficiency or productivity" (SNA 1993, Par. 6.163). Expenditures such as manufacturing start-up which include engineering, tooling, plant re-arrangement and construction and installation of equipment clearly fall under R&D expenditures according to the SNA. It is important to note that while construction capital and machinery and equipment capital required for these activities are presently classified as capital expenditures (covered by Capital Expenditures Surveys of Statistics Canada) and form part of the stock of capital of Canadian industry, they are not distinguished from other fixed capital of the industry. Those expenditures which are not related to tangible fixed capital (e.g., engineering, plant re-arrangement, R&D marketing expenditures and other start-up costs) are presently treated as current expenditures.

It is clear from this discussion that Frascati's strict definition of R&D lies at the core of what the 1993 SNA considers productivity-improving investments. However, it is also evident that the concept of productivity-enhancing research and development outlined in the 1993 SNA is broader and more inclusive than the strictly technological one set forth in Frascati. For instance, investments related to the implementation of R&D such as technology acquisition, manufacturing start-up and scale-up are all expenditures that are necessary for ascertaining the commercial viability and economic exploitation of newly developed technology. In addition,

introduction of new products and processes very often requires the resolution of marketing uncertainties—such as gauging acceptability of a product or process and the willingness of users to pay prices that cover costs and profit margins—before they can be brought from the laboratory to the market place. Furthermore, basic research conducted by the Business sector should be included in capitalized R&D, while basic research conducted in the public sector should only be treated as capital if research is patentable.

Another issue discussed in the literature is the appropriate treatment of unsuccessful R&D projects given that, by definition, they do not lead to new products or processes. We find this issue analogous to the SNA treatment of mineral exploration. On this issue, the 1993 SNA recommends that all costs related to mineral exploration be treated as capital expenditures, including the costs of test-drilling and costs incurred to make it possible to carry out such tests. The rationale for this treatment is that unsuccessful test-drilling brings the search process closer to fruition and is an unavoidable cost of successful discovery. As the Australian Bureau of Statistics (ABS) paper (2004, p. 3) points out, the output of R&D is valued by summing the costs of projects, rather than market prices that would prevail for (successful) outputs of R&D. Consequently, the costs of unsuccessful R&D are already built into output valuation and require no special treatment.

Finally, there is the issue of how to account for payments in exchange for knowledge transfer. When Canadian firms transfer knowledge produced by R&D to one another, or to foreigners, in exchange for payments, should this always be treated as a sale of R&D or should it be treated as simply a payment? The distinction between the two concepts is critical, because in the first instance, a sale (e.g., an export) would diminish the domestic supply of R&D (available for capitalization) whereas in the second case it is simply a payment that increases the revenue and operating surplus of the recipient. Once R&D knowledge is produced, the owner/producer can sell the rights to the knowledge outright to a domestic or foreign firm, or license its use for a fee to multiple users while keeping its ownership and right to license. Baldwin et al., (2005, pp. 41to 44) argue that whether payments represent sales of R&D or not would depend on the nature of the transaction. In particular, the terms and conditions of the contract, such as the length of time knowledge is made available to the buyer, the right to resale, and whether it confers future benefits, should be examined to determine whether they constitute sales or rental payments.

While there are no unique answers, determining when to treat a transaction as a capital expenditures must be consistent with national accounting principles and concepts such as supply-and-disposition. Although the 1993 SNA calls for only fixed assets to be capitalized, it recognizes that the criterion of ownership is key to capitalization: "The time at which gross fixed capital formation is recorded is when the ownership of the fixed assets is transferred to the institutional unit that intends to use them in production" (SNA 1993, 10.36). This criterion clearly separates sale transactions involving outright transfer of ownership from rental transactions where payments are made in exchange for the right to access knowledge. In the former case, the transaction can be properly capitalized, because it identifies the transfer of R&D knowledge from the institutional unit (industry) where it is produced to where it will be employed in production without double-counting. If the knowledge is exported, the sale would reduce domestic supply. In the latter case, the transaction cannot be capitalized, because while

knowledge is produced once and capitalized, subsequent access to it by other institutional units are instances of use of that output as an intermediate input in other production processes.

What is most important, however, is whether an observed transaction results in the transfer of ownership of R&D output or involves access to intellectual property that must be treated as a rental. Existing surveys of R&D and balance of payments do not identify the nature of transactions.

The study reported in this paper does not treat receipts for patents and licensing at par with receipts from abroad for R&D. Research and development payments and receipts recorded in the balance of payments are considered imports and exports of R&D.[6] Payments for patents and licensing are treated as charges for right-to-use (rental).

4. Depreciation of research and development capital

A key motivation for switching the treatment of R&D from current to capital expenditures is to reflect a more accurate and realistic cost for these activities in industry accounts and sector accounts and, ultimately, in total GDP of the economy. The amount by which R&D assets depreciate in value represents the true cost to society of committing resources to research and development. The existing treatment of expensing the entire cost of conducting R&D in a single year is a significant overstatement of the true cost that detracts from the quality and integrity of the national accounts.

The literature on the subject contains several important conceptual and measurement issues. The literature thus far treats the production of knowledge and the accumulation of a stock of knowledge capital by analogy to physical capital. Research on R&D capital generally assumes that knowledge can be simply accumulated much like buildings or machinery, that each unit added to the stock has a finite life span, and that the market returns from each unit displays one of the patterns widely used to describe services of physical assets, such as straight-line or declining balance. While the analogy is very suitable for statistical purposes, a key difference remains between assets which are productive by virtue of their physical attributes and knowledge assets. All physical assets depreciate and ultimately leave the stock, whereas many forms of knowledge capital retain their ability to produce results indefinitely. Immortality is not only a property of basic science-based research that leads to discoveries in the physical and social sciences, but also much of applied research findings with commercial applications.

For example, the florescent light was introduced following its 1901 patent when it was discovered that sending an electrical change through a tube filled with mercury vapour is a highly efficient and commercially viable method of producing light. The economic returns to the patent owner would decline each year both because of new competing technologies and because of the declining balance of the life of the patent. However, the knowledge that resulted from R&D on florescent light retains its physical productivity until today, enabling small amounts of

6. It is possible that some payments for R&D are received without the necessary transfer of ownership of knowledge assets because of the existence of joint venture or other agreements. Because these cases cannot be identified at this point, it is assumed that all R&D export receipts conform to the criterion discussed earlier.

electricity to generate ultraviolet light, thus permanently raising industrial productivity in terms of obtaining outputs from inputs. Thus, it could be argued that the results of some R&D will be embedded in human heritage permanently and should remain part of a gross stock of knowledge capital. In terms of the net stock of R&D capital, the value of the asset will decline with time and will completely dissipate on or before the end of the term of the patent. The life of a patent may represent an upper limit for the stream of revenues that can be appropriated by the owner of property rights.

Pakes and Schankerman (1984) argue that a prime reason for expecting that revenues associated with knowledge assets decline over time is that newer knowledge will compete with and displace existing knowledge assets. As revenues which can be appropriated by the owner decline over time, the capital value of assets (i.e., the discounted present value of future returns) depreciate without necessarily affecting the physical productivity. It is a widely observed fact of industrial innovation that the most prolific and profitable producers of R&D assets in areas such as micro processors and pharmaceuticals are closely followed by competitors who introduce close substitutes for products and processes of the most innovative firms. For instance, while Intel has been the leading producer of highly profitable new microprocessor technologies in the last two decades, a number of second-tier companies such as Advanced Micro Devices have introduced closely competing products within one to three years that limit Intel's profit potential with remarkable regularity.

The preceding discussion suggests three features for depreciation of R&D capital assets based on the perpetual inventory model (PIM). First, knowledge assets should be discarded or removed from net capital stock of R&D at a point no later than the end of the life of the patent which, in Canada, is uniformly 20 years.[7] Second, because of the heterogeneity of R&D assets, with some R&D markets being more competitive than others in terms of new knowledge creation, it would not be practical to identify different classes of assets and treat them with different rates of depreciation. Instead, a single average rate of depreciation will be selected that best represents the entire population of assets. Third, a geometric depreciation function should be used which allows for more accelerated depreciation earlier in the life of the asset. The current literature on R&D capital stock, such as the work done by the Bureau of Economic Analysis (BEA) (Fraumeni and Okubo, 2004 and 2002), ABS (2004), the Office of National Statistics (Clayton and Vase, 2004) and Statistics Netherlands (de Haan and van Rooijen–Horston, 2004) incorporate all three features with some variations.

The BEA also uses the PIM to construct stock and capital consumption values for the U.S. satellite accounts. Their choice of an 11% rate of geometric depreciation reflects the mid-point of a range of estimates of service life based on earlier research. This corresponds to an 18 year life-span for the straight-line pattern.

The United Kingdom's Office of National Statistics (ONS) uses much of the methodology of the ABS to estimate R&D capital using the PIM. ONS estimates use the growth rate of investment and depreciation rates, as we do, to estimate an initial value for the stock of R&D. R&D capital is estimated using a geometric depreciation pattern with alternative rates of 10%, 15% and 25%

7. This is based on information provided by the Canadian Intellectual Property Office.

per year applied uniformly to all capital stock without discriminating by type of R&D or by industry.

The estimates of R&D capital stock and capital consumption presented in this paper are obtained using a PIM applied to R&D capital expenditures estimates described in this paper. These series are estimated for Canadian business sector industries at the S level of aggregation (about 20 industries) as well as for the federal government, provincial governments and universities. The stock of R&D capital is estimated at replacement cost in both current and constant prices with a corresponding series for consumption of R&D capital. Net capital stock is calculated using a geometric (concave or declining balance) depreciation pattern truncated at 20 years, reflecting the maximum longevity of economic returns from patents, which expire after 20 years in Canada.

Although Bernstein and Manuneas (2004) estimate geometric depreciation rates for U.S. manufacturers ranging from 18% to 29% per year, most of the literature on R&D capital use rates ranging from 9% per year to 25% per year (see, for example, ABS (2004) and Hall and Mairesse (1995)). We have presented two sets of estimates, based on the two extremes of 10% and 25% annual geometric depreciation. Consistent with existing research, we also find that the rate of growth of constant price capital stock is not very sensitive to the assumed rate of depreciation. For instance, the average annual growth of non-business R&D capital varies from a high of 3.0% per year with 10% per year depreciation, to a low of 2.8% when we assume a depreciation rate of 25% per year. However, the level of capital consumption is always sensitive to the rate of depreciation that is assumed. Capital consumption rises sharply (by 34%) as we go from assuming a low of 10% per year to 25% per year capital depreciation.

5. *Deflation of research and development*

A second set of issues related to the calculation of capital stock concern volume estimates, or how to deflate investment and stock estimates to obtain constant price estimates. Volume estimates are important for measuring the flow of services that can be obtained from stocks of R&D capital for productivity measurement and for estimating the user cost of R&D capital. Because transactions in R&D assets are scarce and, when they do occur, the unit prices are not observable, there are no price indices that relate to outputs of R&D.

One way of dealing with this situation is to construct a price index for an "output" of R&D products from information about intermediate and primary inputs that are used to produce R&D. Among many drawbacks, this approach models the output of R&D as simply the sum of inputs of R&D, overlooking the critical fact that the value of new knowledge emanates not from how much work it took to find, but from the economic value of what was discovered. In addition, experimental work along this approach is too scant (see Statistics Canada, 1986) to allow a full assessment of whether it would likely produce satisfactory volume measures. This approach was not pursued for the present paper.[8]

8. One experiment that constructs expenditures price indices by aggregating price indices for intermediate and primary input components of R&D expenditures is a study by J. Bernstein published by Statistics Canada (see Statistics Canada, 1986).

An approach that shows potential promise is to use a price index that is an aggregate for observable rates charged by primary producers of R&D-type services. The ABS estimates a price index for R&D using this method. However, the ABS has not used these deflators to estimate R&D capital stock because the available time series does not extend back far enough to be used with the PIM. The approach followed by the U.S. Bureau of Economic Analysis is to use the general investment price index, the index of private fixed non-residential investment prices, to deflate R&D (Fraumeni and Okubo, 2004, p. 13).

Another approach that is widely followed in the literature is to use a price index that is more broad-based than investment and would capture more general price movements. We have also used this approach and applied the price index that covers the largest basket of goods and services that affect R&D, the chain-linked GDP deflator, to deflate R&D expenditures for both Business and Non-business sectors.

6. *Capitalization of research and development in the Canadian SNA*

The present System of National Accounts (1993 SNA) treats research and development as current expenditures, whether purchased or carried out in-house by businesses for final use. Expenditures on R&D by governments or non-profit institutions are treated as final expenditures (i.e., included in GDP), but they are nevertheless current consumption rather than investment and, as such, do not appear as private or public capital stock or as part of the net worth of the Canadian economy.

Capitalizing R&D expenditures involves a number of adjustments and adaptations, shown here as a bridge table, in order to transform Statistics Canada's Frascati-based R&D data to be in line with SNA concepts and definitions. The industry output and input of R&D must be estimated for each industry in the Canadian input-output tables. The estimates are also needed for the total amount of capitalized R&D by the Business and the Non-business sectors. Before outlining these steps, we remind the reader that the capitalization exercise shown in this paper does not follow some of our recommendations because appropriate data are not yet available. Specifically, we have argued that basic research conducted in the public sector that is not patentable should be excluded from capitalized R&D, whereas a number of R&D-related activities not covered by the Frascati Manual's definition such as pre-production expenditures should be included. These steps are omitted in the preparation of estimates for this paper but will be presented in the future as components of an R&D satellite account.

7. *The output of research and development*

As a first step, we calculate the R&D output of each business sector industry as well as universities and governments (non-business R&D). The output of R&D is calculated separately for the Business and the Non-business sectors. SNA values production at basic price, that is, "the amount receivable by the producer from the purchaser for a unit of good or service produced as output minus any tax payable, and plus any subsidy receivable, on that unit as a consequence of its production or sale. It excludes any transport charges invoiced separately by the producer".

(SNA 1993, 6.205). The Canadian SNA values output at *modified* basic price, a valuation that conforms to the concept of basic price but excludes subsidies on products receivable by producers.[9] Therefore, it is equivalent to a factory gate price which is observable for statistical purposes. In this system, subsidies are recorded as revenues of industries receiving them. Hence a negative entry in the amount of the subsidy appears in the account of the receiving industry. Therefore it is necessary that the amount of product subsidies reported in the form of government grant in the survey is subtracted from present R&D expenditures to obtain the valuation of output at modified basic prices.

The 1993 SNA specifies that own-account R&D activities "should be valued on the basis of the estimated basic price that would be paid if research were sub-contracted commercially, but is likely to be valued on the basis of the total production costs, in practice. The total cost is the sum of intermediate consumption, compensation of employees, consumption of fixed capital and other taxes less subsidies on production. Research and development undertaken (for sale) ".... is valued by receipts from sales, contracts, commissions, fees, etc. in the usual way." (SNA 1993, 6.142). Market production of R&D includes the operating surplus of the industry.

The current expenditures on R&D based on the Frascati Manual consist of labour costs and other costs. The sum of labour costs and other costs[10] includes subsidies but excludes taxes on production (OECD (1) 2002, Table 5, 177). It does not include the purchases of R&D from abroad nor the consumption of fixed assets used in the production of R&D. It does not include net operating surplus applicable to sales of R&D.

The output of R&D by industry is estimated by components which make up the gross output (GO) of R&D shown in equation (1) (see Table 1A in Appendix).

For the Business sector, GO is:

(1) $GO = L + OC + CC + NOS + TP - GS - SW - ME$

For the Non-business sector, GO is:

(2) $GO = L + OC + CC - SW$

Where:
L is labour costs;
OC is other current costs;
CC is consumption of capital;
NOS is net operating surplus;
TP is other taxes (net of subsidies) on production;
GS is product subsidies;
SW is software development;
ME is mineral exploration.

9. Another limitation of the basic price concept is that "any subsidy on product is treated as if it were received directly by the purchaser and not producer" (SNA 1993, 6.206). This means that subsidies must be allocated to users of subsidized products, i.e., to industries and final users. This would require identification of commodities involved as well as industries and final users who benefit from subsidy programs. This second step poses a particular estimation difficulty since business records contain no information on who benefits from subsidy programs. Canada's "basic prices" does not encounter the difficulties of identifying the beneficiaries of subsidies.

10. The other costs represent purchases and therefore there could be a difference between purchases and the materials used.

8. Overlapping expenditures

The existing data on Frascati-based R&D expenditures data include two overlapping expenditures, in the sense that they are already part of the SNA capital formation and must be excluded in order to avoid double-counting. These are computer software expenditures and mineral exploration expenditures.

i. Data collected according to the Frascati manual includes computer software. According to the manual "in addition to the software that is part of an overall R&D project, the R&D associated with software as an end product should also be classified as R&D" (OECD (1) 2002, p. 136). Statistics Canada survey *Research and Development in Canadian Industry* includes a question on the percentage of R&D expenditures that is attributable to software development. These percentages apply to both current and capital expenditures of performers. Pending a revision in the questionnaire, the percentages were applied to R&D current expenditures of each industry to estimate the amount of software that must be deducted from the total performer's expenditures to avoid R&D overlap with software. For the Non-business sector, the values of software were taken from the input-output tables.

ii. The second overlapping expenditures relates to mineral exploration. The 1993 SNA already includes in gross fixed capital formation the cost of actual test drilling and boring together with the "costs incurred to make it possible to carry out tests" (SNA 1993, 10.91). This definition of mineral exploration overlaps with the Frascati definition of R&D in mineral exploration. According to Frascati, this includes "the development of new or substantially improved methods and equipment for data acquisition and for the processing and study of the data collected and for the interpretation of these data; surveying undertaken as an integral part of an R&D project or geological phenomena per se, including data acquisition, processing and interpretation undertaken for primarily scientific purposes" (OECD (1) 2002, p. 107). In the absence of accurate data on the amount of overlap, R&D data reported by respondents classified to Support Activities for Mining industry were taken as the amount of double-count.

9. Capital consumption

In computing equations (1) and (2) above, capital consumption for fixed capital assets used in the production of R&D was estimated by first calculating the level of capital stock by industry using the perpetual inventory method (PIM) applied to capital investment data reported in the R&D survey. In this process, the PIM is used with the same assumption about discards, asset life and depreciation patterns that are used presently for all of the capital stock of the industry. From these stock series, a capital consumption series is estimated that is consistent with the existing industry estimates of capital consumption.

10. Net operating surplus

Another cost item that enters equation (1) is operating surplus associated with the market R&D performed by each industry. In arriving at this estimate, we assume that all input-output industries that perform R&D as a secondary activity have the same cost structure as the industry that is the primary producer of R&D, that is, NAICS industry 54171 Research and Development in Physical, Engineering and Life Sciences.[11] Data on profitability of R&D for this industry, developed from tax sources, is used to estimate net operating surplus on sales of all industries as required by equation (1).

11. Taxes and subsidies

Government subsidies on products were obtained from the R&D survey which is collected under the rubric of government grants. Taxes on production were estimated using the ratio of R&D capital stock to total capital stock in each industry.

12. Own-account output

The gross production of non-market or own-account R&D for each industry is estimated with equation (3) (see Table 1B in Appendix). Because the data are not collected on own-account output explicitly, it is calculated residually. The own-account output is equal to total R&D output less sales of R&D to exports and sales to other entities in Canada. It can be represented as:

(3) $OO = GO - S - X$	Where: OO is own-account output; S is sales within Canada; X is exports.

In this project, research and development that is conducted by industries on own account is assumed to be inventories for one period (one year) before it is presented as final production that is shown both as output and as capital investment. The rational for choosing to lag the production of R&D is that the production of knowledge is time-intensive and, almost by definition, does not lead to instantaneous final output. This follows the approach taken by the U.S. Bureau of Economic Analysis in their estimates of R&D satellite accounts which uses a one year lag but also considers arguments for lags of up to seven years (See Fraumeni and Okubo, 2004, p. 14). The BEA satellite accounts lag all R&D expenditures by one period since they do not separately estimate market R&D, which is sold as final output, and own-account R&D which is used

11. Entities performing R&D as their principal activity are classified under NAICS industry 54171 Research and Development in Physical, Engineering and Life Sciences. This industry is presently classified with input-output industry "Other professional, scientific and technical services". In order to capitalize R&D, the industry will be articulated separately under a revised input-output industry and commodity classification. Similarly, R&D output which is presently included in a composite commodity "Other professional and scientific services" will be shown as a separate commodity output.

internally. Since these components of R&D production are separately estimated for this project, only own-account R&D is placed in inventory.

13. Sales within Canada

The Statistics Canada R&D survey collects information on sources of funds which form the basis for estimating R&D sales in Canada. These estimates were adjusted in the light of input-output data.

14. Trade in research and development

Frascati's definition of R&D covers only domestic intra-mural expenditures. Canada is an open economy with a sizable trade in intellectual property. To obtain domestic R&D fixed capital, among others, imports of R&D must be added and exports of R&D must be deducted. For the year 2000, imports of intellectual property were roughly 27% of total imports of commercial services while exports were 36% of commercial services. The imports and exports in intellectual property consist of R&D services, patents and industrial design, trademarks, and copyrights and related rights. Data in the input-output tables reflect the international trade data. Statistics Canada's R&D survey provides information on research financed by foreigners as well as purchases of R&D by domestic firms from abroad. In effect, these values are exports and imports respectively. Some important shortcomings of these series are that companies with less than $1 million of R&D expenditures are not covered and that the survey is confined to R&D performers. Import and export data were compared with Canadian balance of payments data and adjusted where necessary. Specifically, the survey's undercoverage compared to the balance of payments was 24% for imports and 17% for exports for the reference year 2000. Since the year 2000 balance of payments data show that Canada is a net exporter of R&D by about $2.5 billion (42% of the R&D trade), this results in reduction of R&D that remains in Canada that can be capitalized. Data on rental of intellectual property in Canada are available from input-output tables. The fees paid to, and received from, the owners of innovation in the form of patent, trade mark, industrial design and licenses are already reflected in the input structure of the industries as rentals. But these rentals are not shown as relating to innovation. However, no data is available on outright purchases of intangible capital such as patents and trade marks. This information should be included in the satellite account on R&D and innovation, as discussed later in the paper.

(4) $R\&D = OO_{t-1} + M + P$

Where:
OO is own-account production of R&D lagged one year;
M is imports;
P is purchases from other sectors in Canada.

15. Research and development investment by industry

We need to estimate the R&D investment for each input-output industry. As equation (4) shows, this is the sum of own-account capitalized R&D produced in the previous period, purchases of R&D from other sectors in Canada, and imports of R&D from abroad (see Table 1C in Appendix).

The Statistics Canada survey of R&D calculates information on the purchase of R&D from Canadian and foreign sources. These values for domestic purchases were compared with sales data and adjusted as needed based on data from the input-output tables.

16. Impact of capitalization on gross domestic product

When Canadian industries' expenditures on R&D-related activities are reclassified as capital expenditures using equations (1) through (4) above, the values of existing measures such as gross industry output and gross domestic product will be impacted. The value of gross output of business industries will increase by the amount of own-account R&D production, shown as a separate commodity output for each industry. However, explicit recognition of market R&D as output does not have any impact on total (gross) industry output, since it is already included as an industry output.

The income-based GDP will increase by the amount of R&D capitalized by the business sector, plus the capital consumption of R&D capital in the non-business sector.[12] This is consistent with existing national accounting practices which impute no return to fixed capital used in the non-business sector.[13]

The components of the expenditures-based GDP will be affected as follows: the personal expenditures will not experience any change because no R&D is recorded for non-profit institutions serving households. The government current expenditures will decrease by the amount of capitalized R&D but will be higher by the amount of capital consumption of the sector's R&D capital stock. The inventories will change by the (lagged) amount of own-account production.[14] The fixed capital will increase by the amount of (lagged) own-account and purchased R&D of the Business and the Non-business sectors. There will be no change in international trade in R&D.

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12. Estimation of this component of capital stock and depreciation are discussed under the section "Depreciation of R&D capital".
13. The U.S. Bureau of Economic Analysis imputes a rate of return to all government capital stock to improve the comparability of measures of capital. This includes the stock of R&D capital for general government. BEA's implementation of R&D in the U.S. national accounts shows a larger proportional impact on GDP compared to the present exercise, but "...the largest current dollar net addition to GDP is the addition from imputing a net return to general government capital" (Fraumeni and Okubo, 2002).
14. These changes are not reflected in the present paper.

Table 1 Gross domestic product (GDP) income–based, 2000 ($millions)

	Existing	Capitalization: all R&D[1]	Difference	Capitalization: all but basic R&D[1]	Difference
Net indirect taxes	128,338	128,338	0	128,338	0
Labour income	545,204	545,204	0	545,204	0
Operating Surplus	403,034	415,876	12,843	414,055	11,021
Total GDP	1,076,576	1,089,418	12,843	1,087,597	11,021

1. Research and development.
Source: Statistics Canada.

Table 1 shows the impact of capitalization of R&D on GDP for the reference year 2000.

As shown in the table, GDP for reference year 2000 will increase by $12.8 billion, representing 1.2% of total GDP. On the other hand, if we assume that ratios similar to those of the United States prevail in Canada—namely that 66% of universities' R&D is basic research and 25% of federal government R&D is basic research—removing basic research from capital expenditures using the U.S. shares would lead to a GDP increase of only $11.0 billion (or 1.0%).

It should be noted that while the total amount of Gross Expenditure on R&D (GERD) in 2000 was $19.1 billion, capitalized R&D calculated as part of this exercise is only $15.8 billion, largely due to net export of R&D.

Table 2 Gross domestic product (GDP) expenditures-based, 2000 ($millions)**

	Existing	Capitalization: all R&D[1]	Difference	Capitalization: all-but basic R&D	Difference
Personal expenditures	596,010	596,010	0	596,010	0
Government expenditures	200,084	197,076	-3,008	198,883	-1,201
Fixed capital formation	206,273	222,123	15,851	218,495	12,222
Change in inventories	12,277	12,277	N/A*	12,777	N/A*
Exports	490,686	490,686	0	490,686	0
Less imports	428,754	428,754	0	428,754	0
Total GDP	1,076,576	1,089,410	12,843	1,087,597	11,021

1. Research and development.
* No changes in inventories are shown in this table as inventories of research and development for prior years were not estimated as part of this exercise
** Assuming universities perform 66% and governments 25% of basic research, as in the United States in 1997
Source: Statistics Canada.

17. A satellite account for research and development/innovation

The conceptual and statistical issues discussed in this paper clearly illustrate that capitalization of R&D can be accomplished in a number of different ways. The choices include the boundary of R&D activities which involve scope issues such as the treatment of pre-manufacturing investment, the inclusion of certain kinds of basic research, as well as statistical issues such as

the life of R&D assets, depreciation patterns and price deflators. Clearly, the choices made along any of these dimensions directly affect the level and the rate of growth of net R&D capital stock.

The paper has also indicated that some of the data required for the approach proposed here are not presently available. Indeed, not all of the data needed for capitalizing R&D based on a strict 1993 SNA definition are presently available. The existing data on current and capital R&D expenditures based on the Frascati Manual are not fully adequate for suitably estimating the level of capital stock and capital consumption of R&D.

In addition, the boundary between the production of software and the production of R&D has not been clearly established. As a result, certain expenditures can be classified both as software and as R&D, be they output or capital expenditures. It is not difficult to imagine how data on each class of expenditures would be useful for analytical studies. Data needs of such studies can be accommodated through a satellite account that incorporates both software and R&D series in spite of a substantial overlap between them. In order to incorporate these expenditures into SNA core accounts, definitional issues need to be resolved and mutually exclusive classifications need to be created.

It is reasonable to expect that the present situation marked by unsuitable data sources, rough estimates and lack of consensus on basic concepts will continue for some time to come. Clearly, at this early stage in the development of concepts and statistical sources, a satellite account presents important advantages by allowing the flexibility needed for exploring alternative formulations without the constraints of having to integrate the results with core accounts of the SNA.

In addition, as Baldwin et al., (2005, p. 8) have argued, *innovation* which is a broader issue than R&D expenditures, is critical to growth and competitiveness in Canada's unique economic position: "If Canada were to only capitalize R&D expenditures and not science-based expenditures, we would significantly bias estimates of Canadian GDP relative to those for other countries, such as the United States, whose innovation systems utilize more traditional R&D expenditures" (Baldwin et al., 2005, p. 10).

A satellite account would provide the flexibility of amassing all innovation-related activity in a comprehensive manner, such as trade in R&D, rental of intellectual capital, and science-based knowledge capital. It would encompass activities ranging from discovery, product/process improvement, commercialization, market development and trade in knowledge products including payments for royalties, licence fees, patents and industrial designs. It should be noted that while purchases of intellectual property, such as a patent, would be considered a capital expenditures that adds to the stock of R&D capital, payments by one institutional unit to another for simply accessing it would not be treated as capital expenditures. Payments such as license fees that simply permit access to intellectual property for a fixed period of time, where the rights are extinguished at the end of the period, are more properly treated as rental payments analogous to rental of machinery and equipment. This is in contrast to the treatment recommended by the OECD Task Force on Software Measurement which calls for capitalizing all rental and licensing payments for software.[15] The rentals in current and constant prices measure inputs of these

15. See Lequiller et al., 2003 Recommendations 1(7) and 1(8).

services into the production process better and more directly than measures that infer the value and flow of services from a stock of capital generated using a PIM methodology.

All of the above considerations support our recommendation to develop a satellite account that incorporates all R&D/innovation related activities outside the existing core accounts of the SNA.

18. Concluding remarks and recommendations

We have considered three key issues relating to capitalization of R&D expenditures in the System of National Accounts. First, we explored criteria and recommendations in both the Frascati Manual and the 1993 SNA and considered the views of Canberra II Group participants on the question of what "should" be included in R&D investment. We have outlined compelling arguments that the Frascati Manual's definition of R&D includes certain research activities which fall outside the SNA investment definition. These include basic research in both the social and the natural sciences conducted in the public sector which are not patentable and enter the public domain where no property rights can be exercised. However, with this exception in mind, the paper recommends that all patentable research conducted in the public sector and all research conducted in the Business sector should be capitalized.

Another issue of equal importance is certain non-research R&D expenditures which are excluded from the Frascati Manual, but are consistent with SNA criteria and principles. This research finds compelling arguments that expenditures such as patent filing, licensing, pre-manufacturing start-up and redesign should be treated much like other productivity-enhancing innovation activity and should be included in R&D capital expenditures. However, it recommends that payments for access to intellectual property (such as payments under a licensing agreement) be treated as rental payments to institutional units who own the capital rather than as investment expenditures.

Next, the paper outlined the steps that are required to transform Statistics Canada R&D data to estimate domestic outputs of R&D and R&D capital expenditures consistent with the Canadian System of National Accounts. In addition, the paper outlined statistical issues involved in arriving at estimates for exports and imports of R&D where the existing survey and balance of payments data are competing sources. Issues and choices related to developing capital consumption and capital stock measures for the newly developed R&D investment series are also outlined. The paper presents estimates for reference year 2000 for both income-based and expenditures-based GDP, pre- and post-R&D capitalization. Aggregate results show an increase of about 7.7% in gross capital formation and an increase of about 1.2% in total GDP.

Finally, the research and statistical implementation of this project support four recommendations for future work in this area. The first recommendation is the creation of a satellite account for R&D and innovation activities outside the SNA core accounts. The principal advantage of a satellite account approach is the great deal of flexibility afforded by a satellite account approach in treating the wide range of innovation and R&D related data. A second and interrelated recommendation relates to data collection and classification of expenditures on software development and R&D expenditures. There is substantial overlap between these classifications at the present time. While this does not present a problem within the confines of a satellite account,

classification and data collection issues that give rise to the overlap must be dealt with before R&D expenditures can be capitalized in the SNA core accounts. The third recommendation relates to improving data collection so that payments for sales of knowledge assets can be distinguished from rental payments for access to such assets. As these two types of transactions must be treated very differently in the accounts, it is important for a proper accounting of R&D capital that data collection includes certain transaction attributes such as whether the ownership of intellectual property is transferred. Finally, the paper recommends that expenditures on patentable basic research be treated as capital regardless of which sector commits the expenditures. In order to implement this recommendation, appropriate data must be collected that would identify patentable projects separately from other expenditures on basic research.

Appendix

Table 1A Research and development (R&D) output ($millions)

Input/Output Industry		1	2	3	4	5	6	7	8
		R&D current exp.*	**Subsidies on products**	**Software**	**Mineral exploration**	**Taxes on productions**	**Capital consumption**	**Net operating surplus**	**Total R&D output 1-(2+3+4)+5+6+7**
1A	Crop and animal production	42	1	0	0	1	4	0	47
1B	Forestry and logging	7	0	0	0	0	0	0	7
1C	Fishing, hunting and trapping	2	0	0	0	0	0	0	2
1D	Support activities for agriculture and forestry	20	3	0	0	1	1	0	18
21	Mining and oil and gas extraction	153	1	1	22	1	30	0	160
22	Utilities	160	5	0	0	5	34	0	195
23	Construction	43	0	3	0	1	4	0	45
3A	Manufacturing	7,667	147	188	0	155	475	70	8,032
41	Wholesale trade	694	2	58	0	21	37	1	692
4A	Retail trade	25	0	13	0	1	6	0	19
4B	Transportation and warehousing	31	0	1	0	0	2	0	33
51	Information and cultural industries	312	2	178	0	4	23	3	162
5A	Finance, insurance, real estate and renting and leasing	183	1	100	0	20	22	0	122
54	Professional, scientific and technical services	1,858	42	734	0	31	99	21	1,234
56	Administrative and support, waste management and remediation services	24	1	3	0	2	2	0	25
61	Education services	3	0	0	0	0	0	0	3
62	Health care and social assistance	280	2	0	0	8	25	3	313
71	Arts, entertainment and recreation	2	0	0	0	0	0	0	2
72	Accommodation and food services	1	0	0	0	0	0	0	1
81	Other services (except public administration)	27	1	6	0	0	2	0	23
	Business sector	11,534	210	1,285	22	251	765	100	11,134
GS	Government sector	7,576	0	681	0	0	349	0	7,244
	Total business plus government	**19,110**	**210**	**1,966**	**22**	**251**	**1,114**	**100**	**18,378**

* This includes labour costs and other costs. See equation (1) in the paper

Note: Details may not add up due to rounding.

Source: Statistics Canada Survey of research and development in Canadian Industry, and Canadian Input-Output Tables.

Table 1B Research and development (R&D) own-account output ($millions)

Input/Output Industry		1	2	4
		Total R&D output	Exports and sale of R&D in Canada	Total own-account output 1-2
1A	Crop and animal production	47	11	36
1B	Forestry and logging	7	0	7
1C	Fishing, hunting and trapping	2	0	2
1D	Support activities for agriculture and forestry	18	7	12
21	Mining and oil and gas extraction	160	5	155
22	Utilities	195	22	173
23	Construction	45	1	44
3A	Manufacturing	8,032	3,336	4,697
41	Wholesale trade	692	35	657
4A	Retail trade	19	1	18
4B	Transportation and warehousing	33	0	32
51	Information and cultural industries	162	162	0
5A	Finance, insurance, real estate and renting and leasing	122	8	115
54	Professional, scientific and technical services	1,234	1,014	220
56	Administrative and support, waste management and remediation services	25	21	4
61	Education services	3	0	3
62	Health care and social assistance	313	152	162
71	Arts, entertainment and recreation	2	0	2
72	Accommodation and food services	1	0	1
81	Other services (except public administration)	23	5	18
	Business sector	11,134	4,779	6,355
GS	Government sector	7,244	682	6,562
	Total business plus government	**18,378**	**5,461**	**12,917**

Note: Details may not add up due to rounding.
Source: Statistics Canada Survey of research and development in Canadian Industry, and Canadian Input-Output Tables.

Table 1 C Capitalized research and development (R&D) by sectors ($millions)

Input/Output Industry		Own-account production	Imports and purchases of R&D in Canada	R&D capitalized by sectors 1+2
1A	Crop and animal production	36	7	43
1B	Forestry and logging	7	5	11
1C	Fishing, hunting and trapping	2	0	3
1D	Support activities for agriculture and forestry	12	2	13
21	Mining and oil and gas extraction	155	81	236
22	Utilities	173	48	221
23	Construction	44	9	52
3A	Manufacturing	4,697	2,111	6,808
41	Wholesale trade	657	145	801
4A	Retail trade	18	9	27
4B	Transportation and warehousing	32	16	49
51	Information and cultural industries	0	61	61
5A	Finance, insurance, real estate and renting and leasing	115	49	163
54	Professional, scientific and technical services	220	313	533
56	Administrative and support, waste management and remediation services	4	6	10
61	Education services	3	2	5
62	Health care and social assistance	162	61	222
71	Arts, entertainment and recreation	2	2	3
72	Accommodation and food services	1	0	1
81	Other services (except public administration)	18	8	26
	Business sector	6,355	2,933	9,289
GS	Government sector	6,562	0	6,562
	Total business plus government	**12,917**	**2,933**	**15,851**

Note: Details may not add up due to rounding.
Source: Statistics Canada Survey of research and development in Canadian Industry, and Canadian Input-Output Tables.

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